DOCUMENT RESUME

ED 466 164 IR 021 235

AUTHOR	Hannafin, Michael J; McCarthy, James E.; Hannafin, Kathleen M.; Radtke, Paul
TITLE	Scaffolding Performance in EPSSs: Bridging Theory and Practice.
PUB DATE	2001-06-00
NOTE	9p.; In: ED-MEDIA 2001 World Conference on Educational Multimedia, Hypermedia & Telecommunications. Proceedings (13th, Tampere, Finland, June 25-30, 2001); see IR 021 194. Contains small print.
PUB TYPE	Reports - Descriptive (141) -- Speeches/Meeting Papers (150)
EDRS PRICE	MF01/PC01 Plus Postage.
DESCRIPTORS	Educational Technology; Information Dissemination; *Material Development; *Military Training; Multimedia Materials; *Scaffolding (Teaching Technique); Skill Development; Teaching Methods
IDENTIFIERS	Navy; *Performance Support Systems

ABSTRACT

Electronic performance support systems (EPSS) help users accomplish tasks, using computational technologies. Scaffolding is the process through which efforts are supported while engaging a learning or performance task. A number of different types of scaffolds are possible, including conceptual, metacognitive, procedural, and strategic. Each of these types of scaffolding is defined in this paper, and a case study involving the application of different scaffolding approaches is presented. The Tactical Readiness Instruction, Authoring, and Delivery (TRIAD) project is developing a set of authoring and delivery tools that will enhance the quality of tactical guidance disseminated through the United States Navy. The bulk of requisite knowledge and skill is developed through experience and personal study of tactical publications (including Tactical Memoranda, or TACMEMOs) and combat system doctrine. TRIAD is a PC-based system being designed and developed to improve the coherence and usability of TACMEMOs. TRIAD will provide authors with an integrated tool set to enable them to create tactical documentation using a variety of multimedia presentation techniques, and to create associated interactive multimedia instruction to support the documented tactic/doctrine. In turn, readers will receive a multimedia tactical documentation "product set" that supports tactic/doctrine presentation and briefing, instruction, quick reference, and facilitation of electronic feedback regarding tactic/doctrine evaluation. TRIAD's online author interview scaffolding of TACMEMOs is emphasized. (Contains 13 references.) (AEF)

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Scaffolding Performance in EPSSs: Bridging Theory and Practice

Michael J. Hannafin
University of Georgia
Athens, GA USA
hannafin@coe.uga.edu

James E. McCarthy
Sonalysts, Inc.
Waterford, CT USA
mccarthy@sonalysts.com

Kathleen M. Hannafin
University of Georgia
Athens, GA USA
khannafi@coe.uga.edu

Paul Radtke
Naval Air Warfare Center Training Systems Division
Orlando, FL USA
radtkeph@navair.navy.mil

ED 466 164

Abstract. Two promising developments have emerged: 1) Electronic Performance Support Systems (EPSS); and 2) scaffolding approaches. The link between these developments, however, is relatively new. The purposes of this paper are to introduce EPSS design and implementation issues, to describe the relevance of scaffolding to EPSS design, and to present a case study involving the application of different scaffolding approaches.

An EPSS Primer

Simply stated, performance support systems help users do or accomplish things as they attempt to perform (Dorsey, Goodrum, & Schwen, 1993); EPSSs do so using computational technologies (Hoschka, 1996). An EPSS is a system of task-integrated online job aids, support tools and information systems that assist users with workplace performance (IETI, 1995; Stevens & Stevens, 1996). While some have expressed the need for caution (e.g., Clark, 1992), EPSS technology has gained broad acceptance in the education and training communities (see, for example, Banerji, 1999; Gery, 1991, 1995; Huber, Lippinott, McMahon, & Witt, 1999; Raybould, 1995). Interest in EPSS technology has been evident in professional organizations, corporate training and education environments, and academic R&D settings (Carr, 1992).

According to Gloria Gery (1995), two simple goals define what *any* EPSS should provide: 1) software to integrate knowledge, data, and tools required to help a performer succeed at a task; and, 2) task structuring that guides performers to create deliverables. In a sense, EPSS technology is not so much a unitary design concept, with fixed features and components, as it is a perspective on designing systems that support learning and/or performing. This, however, can prove elusive and deceptively complex. A recent volume describing the development of EPSS and other tools to support instructional design (van den Akker, Branch, Gustafson, Nieveen, & Plomp, 1999) highlights both the advances realized in the 1990's as well as needed research and development.

A Scaffolding Primer

Scaffolding is the process through which efforts are supported while engaging a learning or performance task. Scaffolding can be differentiated by mechanisms and functions. Mechanisms emphasize the methods through which scaffolding is provided, while functions emphasize the purposes served.

Scaffolding complexity varies according to different contextual variables; scaffolding approaches, therefore, vary accordingly. In some instances where the problem or task is very explicit, scaffolding can be closely linked to the specific performance demands; when the task is not well-known or is ill-defined, scaffolding of a generic nature is generally provided. A number of different types of scaffolds are possible, including Conceptual, Metacognitive, Procedural, and Strategic.

Conceptual Scaffolding

Conceptual scaffolding is provided when the task is well defined and guides users regarding what to consider. At times, this is accomplished by identifying key conceptual knowledge related to a task or creating structures that make conceptual organization readily apparent. These structures can be made available through a variety of mechanisms, ranging from the graphical depiction of relationships, to outlines featuring ordinate-subordinate relationships, to information and hints provided by experts.

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Conceptual scaffolding can be designed to help users reason through complex or fuzzy problems, as well as for concepts where known misconceptions or misunderstandings are prevalent. Hints can guide users to available resources or tools where understanding is typically problematic.

Metacognitive Scaffolding

Metacognitive scaffolding supports the underlying self-management processes associated with performance, i.e., it provides guidance in how to think. Metacognitive scaffolding can be either domain-specific, such as where performance contexts are externally induced, or more generic where the performance context is not known in advance. Metacognitive scaffolding might also remindusers to reflect on the goal(s) or prompt them to relate a given resource or tool manipulation outcome to the problem or need at hand.

Procedural Scaffolding

Procedural scaffolding emphasizes how to utilize available resources and tools. It orients to system features and functions, and otherwise aids the user while performing. For example, some users become disoriented in complex or fuzzy performance contexts. Procedural scaffolding is frequently provided clarifying how to return to a desired location, how to "flag" or "bookmark" locations or resources for subsequent review, or how to deploy given tools. Users need not develop facility with all procedures until they have established, on an individual basis, the need for a given tool or resource.

Strategic Scaffolding

Strategic scaffolding emphasizes alternative approaches that might prove helpful. It supports analysis, planning, strategy, and tactical decisions. It focuses on approaches for identifying and selecting needed information, evaluating available resources, and relating new to existing knowledge and experience. Another type of strategic scaffolding involves alerting the user to available tools and resources that might prove helpful under given circumstances, and providing guidance in their use. Expert advice regarding approaches that might be helpful can also be embedded. Finally, strategic scaffolding may take the form of response-sensitive guidance at key decision points.

Scaffolding in an EPSS: A Brief Case Study

The Tactical Readiness Instruction, Authoring, and Delivery (TRIAD) project is developing a set of authoring and delivery tools that will enhance the quality of tactical guidance disseminated through the U.S. Navy.

Introduction to TRIAD

Decision-makers are faced with increasingly complicated and stressful tactical environments characterized by situational uncertainty, time compression, and capable adversaries. To cope with such environments, today's decision-makers must have absolute command of a vast and varied knowledge base. Decision-makers must be familiar with situational cues, their ship and fleet capabilities and limitations as well as those of potential adversaries, and tactics at his or her disposal as well as those that potential adversaries might employ.

The bulk of requisite knowledge and skill is developed through experience and personal study of tactical publications (including Tactical Memoranda [TACMEMOs]) and combat system doctrine (Cannon-Bowers *et al.*, 1994). TRIAD is a PC-based system being designed and developed to improve the coherence and usability of TACMEMOs. TRIAD will provide authors with an integrated tool set to enable them to create tactical documentation (*i.e.*, TACMEMOs) using a variety of multimedia presentation techniques, and to create associated interactive multimedia instruction (IMI) to support the documented tactic/doctrine. In turn, readers will receive a multimedia tactical documentation "product set" that supports tactic/doctrine presentation and briefing, instruction, quick reference, and facilitation of electronic feedback regarding tactic/doctrine evaluation. In the following sections, we emphasize TRIAD's on-line author interview scaffolding of efficient and effective TACMEMOs.

Author Interview Overview

The TACMEMO development process consists of three stages: interview, edit and review. During the interview stage, the author creates and/or imports existing resources regarding the tactic in response to TRIAD-supplied interview questions. Using the information gained from the interview, TRIAD generates a draft TACMEMO product set consisting of the following integrated components: Base Document, Tactic Training Component, Quick Reference Guide (QRG), Feedback, and Brief. The Base Document contains the core TACMEMO content and procedures. The Tactic Training component addresses training requirements keyed to specific tactics knowledge and skills identified in a given Base Document. The QRG is an on-line job aid designed to distill the most essential aspects of the tactic for ready reference and to enable the user to link to associated Base Document and Tactic Training sections of the TACMEMO. Feedback, of a formative nature related to the tactic's usefulness, is elicited from users and recorded electronically. Finally, TRIAD generates a PowerPoint® presentation Brief containing the primary information contained in the tactic. The Brief can be edited and otherwise modified to provide greater or lesser breadth and depth, per audience needs.

The process begins through progressive decomposition of the product set's content. That is, the author is first asked to specify broad categories of information that the product set will address (*e.g.*, Threats, Weapon Systems, Tactical Employment) and to specify one of these categories as the main thrust of the product set. For example, a given product set may focus on how to use a certain weapon to defeat a certain threat. In this case, the Tactical Employment, Weapon, and Threat categories would all be uses, but the Tactical Employment category would be marked as being the central theme or frame.

After specifying the broad categories of concern, the author breaks each category into smaller and smaller units. For each category, the author is asked to specify which of a set of possible *anchors* are important to the product set. For example, within the Threat category, the possible anchors include Type, Mission, Design Characteristics, Identifying Characteristics, *etc.* This process continues as the author determines which aspects of the anchors themselves to discuss. For example, within the Identifying Characteristic anchor, the author could choose to discuss Identifying Features and/or Indicators via Equipment.

The interview process continues by further decomposing the material to be presented (*e.g.*, creating sub-sections for the base document or learning objectives for the tactic training component) and by eliciting content associated with a particular element (*e.g.*, creating a description of a piece of equipment or a particular practice exercise). Content is added to the skeleton created through decomposition through tools that allow authors to create novel content or select from a library of existing knowledge objects.

The process continues with a guided elaboration and augmentation of the draft product set. The process consists of three iterative strategies, confirming, elaborating, and fine-tuning, designed to help authors refine and augment content. Confirmation assists authors in validating content accuracy and completeness as well as confirming TRIAD generated structures and sequences. Confirmation is critical because it safeguards the accuracy of both the content and structure of TRIAD-generated documents. Elaboration helps authors to extend, amplify, and otherwise augment TRIAD documents. Authors elaborate and detail descriptions and supporting examples, especially those considered critical to the user's knowing and implementing the tactic. Fine-tuning enables the author to clarify information, directions, instruction, and presentation. At this step, the author amplifies key information, reducing or eliminating ambiguity and unclear or non-essential information.

Once the interview is completed and the draft product set generated, the edit stage commences. Here, the author is again presented with the draft product set and can choose to edit any or all of the product set components. The author can add new media and edit existing media (text, graphics, animation, simulation, *etc.*). The author can import related media from the local TRIAD database, or from a remote database, into a product template and then edit as desired.

The review stage commences after all TACMEMO product set components have been developed. Reviewers will be able to comment within the document and return these comments to the author. Comments received electronically will be stored in the TRIAD database for use by the TACMEMO author to revise components as required. The capability to merge comments into the document will be provided. As in the edit stage, the author can create/import new media and edit existing media (text, graphics, animation, simulation, *etc.*) in response to review comments.

TRIAD's Scaffolding

TRIAD is essentially an EPSS authoring environment for producing EPSSs. That is, the authoring environment must support authors as they attempt to produce a TACMEMO "product set" that supports the performance of field users (readers). It is useful, therefore, to consider TRIAD as a family of EPSSs, some designed to aid the author's performance and others to support readers' performance. In Table 1, we summarize TRIAD's scaffolding features.

Scaffolding assists individuals as they engage various activities. For example, conceptual scaffolding assists the learner in defining what to consider. Within TRIAD, the searching mechanisms described earlier also function as *conceptual scaffolds* by directing the users' attention to product sets and sections that are likely to contain the most relevant information. At a macroscopic level, the majority of conceptual scaffolding actually takes place during authoring. By enforcing a performance-focus during authoring, TRIAD ensures that the base document, tactic training component, QRG, and brief indicate to the user the key concepts within a given product set.

Metacognitive scaffolding is provided through the practice and assessment area in the tactic training component. These sections provide a definitive indication of what each user knows. Rather than just providing an indication of correctness, these spaces try to capture "teachable moments" and deliver guiding feedback to users. *Procedural scaffolding* is provided through a task-oriented help system and results-oriented tool tips. Rather than defining buttons and functions, TRIAD's help system and pop-up tips describe how to complete tasks and explain the consequence of using a control. The TRIAD navigational construct is another procedural scaffold. Depending on user actions, this construct provides a table of contents, an index, or a list of the active bookmarks.

Conclusions

Scaffolding is a natural "fit" in EPSS design since, by definition, the systems guide or facilitate task completion. Scaffolding provides a more principled approach, however, in that it differentiates among the different types of both performance support needed and the methods/media used to support performance. This paper and presentation focused on defining and differentiating among scaffolding levels and illustrating their applicability in an ongoing R&D initiative. We believe the principles are more broadly applicable across a range of both performance support and knowledge system support. Future efforts should demonstrate scaffolding's viability accordingly.

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TRIAD Scaffold	*Description*	*Example*
Guidance	Context-/task-sensitive advice and clarification for performing, completing, or understanding the task at hand.	If a topic discusses a new piece of equipment, an illustration may improve the discussion by showing the new features or changed aspects of the equipment. Likewise, a textual discussion of complex information often benefits from a tabled summary of the presented data and information. Use the following 'Select if table' to help you decide how the information can best be presented. Select 'Table' if it is important to summarize complex data &/or information. Tables organize information &/or data to be summarized into rows & columns labeled in ways that make sense given the information. For example, create a table that lists different types of equipment in rows and the conditions/constraints for employment in each column. Select 'Graph' if it is important to visually present data for two or more critical variables in order to aid the reader's understanding of how variables interact along a particular continuum. For example, create a graph that illustrates trajectories of various projectiles. Select 'Illustration' if it is important to identify the visual aspects, features, or variations of parts, components, or processes for the reader. For example, create an illustration that displays numbered sequences indicating the path water follows when flowing through a particular valve system.
Definitions	Operational definitions of important terms that need to be understood in order to complete, perform, or understand the task at hand. The following are example definitions,	"A good annotation is a concise statement that provides a critical explanation or description." " A performance goal describes the expected performance of the trainee and it helps focus the author's writing on the required performance."
Examples	Completed exemplars or models demonstrating the task at hand , e.g., an example summary statement; an example assessment item.	
Explanation	Additional related information regarding the task at hand. The following is an example of AI provided after receiving Guidance to review a particular performance goal for clarity, accuracy, and completeness.	To determine if a goal should be edited: Read for clarity. Read the goal aloud and if you 'stumble' while reading, the statement is probably too wordy. Edit it by removing any unnecessary words. Read for accuracy. If the verb does not reflect the desired performance, select another verb from the verb table. Read for completeness. Read the goal and make sure it describes the required performance completely (subject, verb, object).

Wizard	Provides two types of information: 1.) a numbered step-by-step listing of the sequential steps to be followed when completing a given task; and,	This task requires you to refine and clarify the text by either adding missing detail or deleting unnecessary detail. Read each section and ask yourself the following questions: Is the text understandable and able to 'stand alone' without further detail or explanation? That is, is the information complete? If not, you'll need to add additional detail or explanation. As you read each topic, ask yourself if the information presented is complex (e.g., involves multiple steps) or is difficult to understand (e.g., easily confused with similar concepts). If so, emphasize each important step in a bulleted or numbered list. If the concepts are difficult, underscore how the concepts are dissimilar/similar by developing a list which compares/contrasts the similarities and/or differences. Additionally, as you read each section ask yourself if too much information or too many examples have been included. If so, edit to be more concise. Delete any descriptions/explanations that are not unnecessary.
	2.) guiding questions or reminders aimed at helping the author think about initiating, completing, or confirming a to-be-completed task. The Wizard is a 'pop-up' feature and can be disabled by the author.	This task requires you to inventory all existing media and documentation. Gather together all supplemental documentation and media that you'd like included in the memo. Read each topic heading and click 'Yes" to indicate you have an existing piece of media or documentation that is relevant to the topic. Type the name of the item so that it can be easily identified later. For example, Graph: Typical trajectory of a … When you have completed inventorying all existing items, press ENTER to continue. Remember, if you'd like to read your memo in its entirety, select the 'View' button.
SCREEN CAMS	Screen Cams introduce and demonstrate new procedures, e.g., dropping & dragging topics into an outline. Screen Cams combine the 'live' movement of the cursor with a simultaneous voiceover that describes how to complete each required step in the procedure.	SCRIPT: In this section you'll indicate which topics are essential and which are supplemental. This distinction determines where topics are placed within the document's main text or appendices. Review the displayed topic headings. Notice as you roll the mouse over a topic heading the drafted content appears. You are going to click on each topic heading you consider essential to Knowing/Performing the tactic. You will continue this process until all topic headings are reviewed. Remember, your goal is to develop a concise memo and the main text should contain only the information and procedures that are essential to Knowing/Doing the tactic.
HELP	System-wide TRIAD HELP. Includes editing, navigation, etc. rather than task-specific guidance.	

Table 1. TRIAD's scaffolding features.

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